Re-Refining and the European Market

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Re-Refining and Sustainability

❑Re-Refining process is sustainable

- ➢ Represents closed loop process where UMO collected, processed, formulated and re-introduced into high performance products
  - ✓ All used oil products recovered and reused
  - ✓ Base oil, water, fuel, asphalt bottoms
- ➢ Base oil(s) returned to original quality
  - ✓ Most base oil components do not degrade
  - ✓ Additives main source of oil degradation

❑Process good for the environment

- ➢ Collect, recover and re-use
  - ✓ Process can be repeated indefinitely
- ➢ Contributes towards CO_2 reduction
  - ✓ Produce more base stock vs crude oil
  - ✓ Formulate mid-high tier products
  - ✓ Engine and industrial oils, driveline products

Re-Refining Capacity – Global and Regional

❑Re-refining represents ~3.7% of global capacity

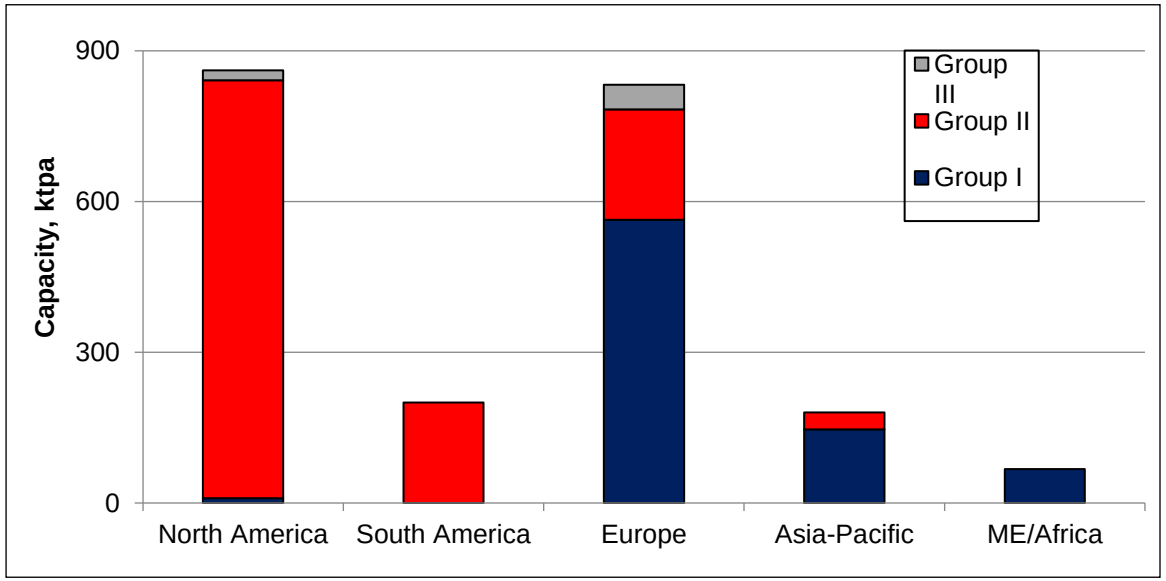
- ➢ Growth opportunities remain bright, opportunity to leverage LCF attributes

❑Currently 25 plants with capacities >20 ktpa

- ➢ Key regions North-South America and Western Europe, opportunities in SEA and India
- ➢ Many small plants under the radar screen (mostly Group I or produce VGO)
- ➢ New capacity announcement by LWART (100 ktpa) in 2025; export opportunities
- ➢ Pentas-Flora Malaysia recently launched new Group II^{+} and III, growth continues in Europe

❑Nearly 60% of RRBO production now Group II and Group III

- ➢ Trend continues with improving feed quality, process technology advancements



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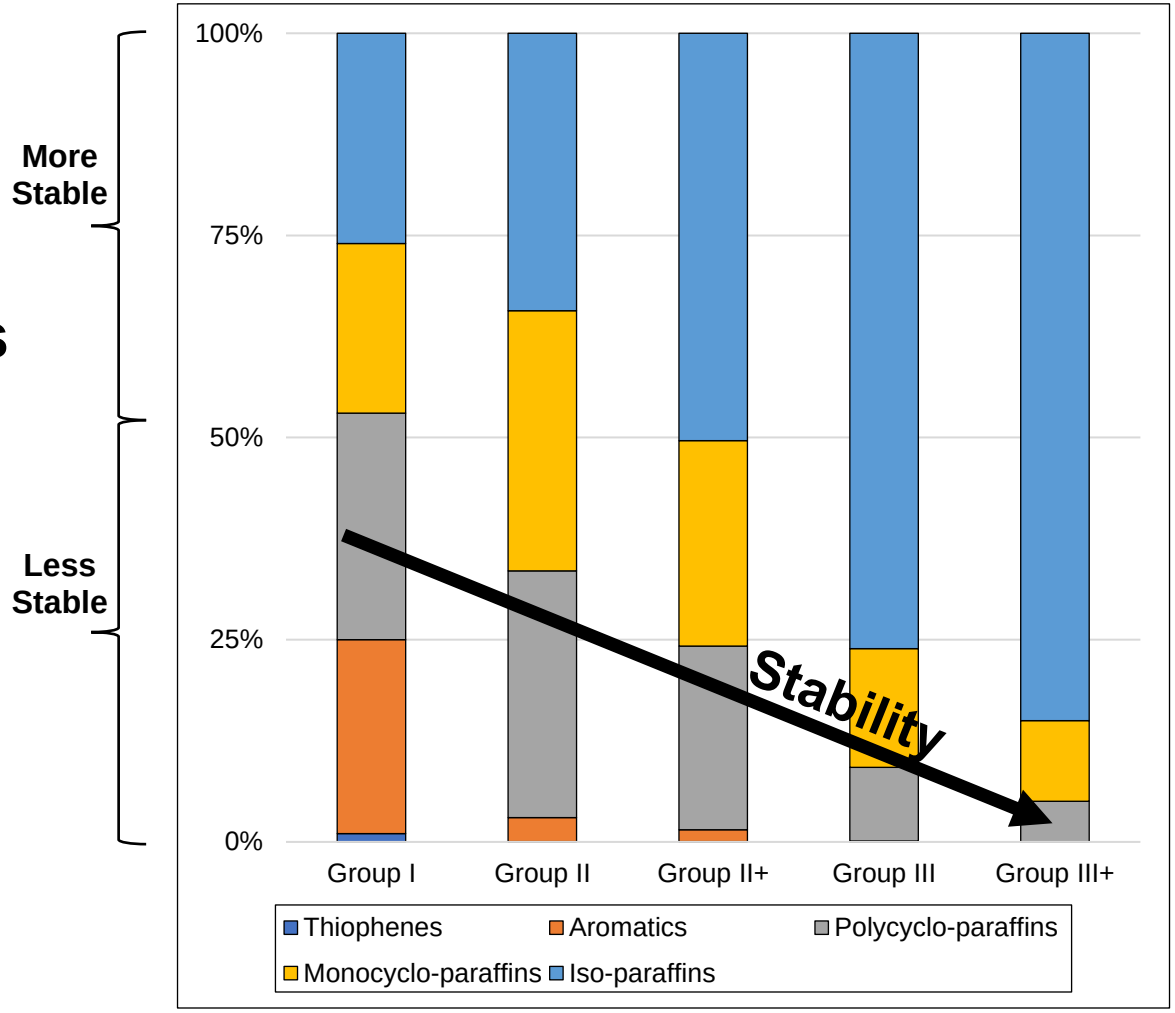
Feed Stock Selection Key to Process

- **Used oil collected from many sources and locations**
  - Variability makes initial feed assessment critical
- **Not unusual to extensively test used oil deliveries for key properties prior to acceptance**
  - Viscosity, gravity, water content, flash point
  - Metals, chlorides, PCB, VOC, glycols, pH, solids, GCMS
- **Analysis determines used oil feed value, disposition**
  - Options include re-refining, re-cycling, burning, landfill, rejection
- ***Remember – What you collect reflects what you make***

Acceptable Sources	Potential Problem Sources
Engine Oils	Heat Transfer Oils
Transmission Fluids	MWF, Cutting Oils
Gear Oils	Parts Washer Fluids
Hydraulic Oils	Some Transformer Oils

Base Stock Composition Varies with Processing

- **Solvent processing (Group I) retains sulfur, aromatics**
  - Unstable components
  - Degrade when exposed to high temperatures
- **Hydroprocessing converts aromatics to paraffins; removes sulfur**
  - Creates a more stable composition
- **Modern engine oils use hydroprocessed base oils**
  - Stable components remain thru oil use
  - Recovered almost completely with re-refining
- **Contributes to closed loop process**



Source – KEPC estimates

Formulation Sciences – The Beginning of the Re-Refined Base Oil Story

❑Engine oils designed to highest performance standards

- ➢ Deliver fuel economy, reduced volatility, extended drain/reliability
- ➢ Normally formulated with hydroprocessed Group II or Group III (VI, Noack, CCS)

❑Industrial oils need viscosity; formulated typically with Group I or Group II

Examples	SAE 5W-30 PCMO			Industrial Oil	
Component, %	**Synthetic**	**Synthetic Blend**	**Conventional**	**ISO 32**	**ISO 100**
Group III/III$^+$	~80	10 to 50	0	0	0
Group II$^+$	0	0	~80	0	0
Group II	0	30 to 70	0	150N Group I or Group II	500-600N Group I or Group II
Group I	0	0	0		
Adpack	8 to 12	8 to 12	8 to 12	0.5 to 2.0	0.5 to 2.0
VM/PPD	5 to 10	5 to 10	5 to 10	0.0 to 0.5	0.0 to 0.5
Total	**100**	**100**	**100**	**100**	**100**
Group II$^+$ can be blended from Group II$^+$ Group III/III$^+$					

❑Why is this important?

- ➢ This is the feedstock source for re-refining!

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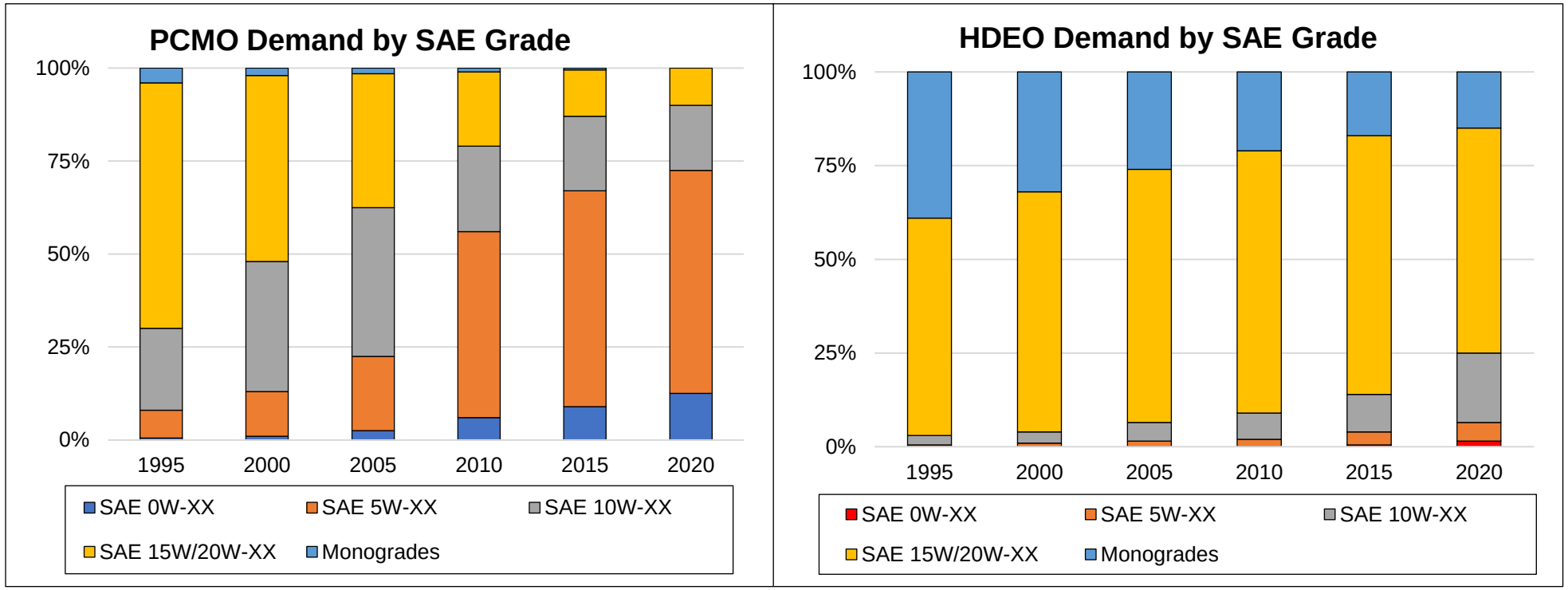
Re-Refined Feedstock Quality – Europe

❑PCMO and HDEO qualities continue to improve

- ➢ Low SAE 0W-XX and SAE 5W-XX grades require premium base oils
  - ✓ Industry approvals typically achieved with Group III quality
  - ✓ Industry + OEM approvals extend need to Group III^{+} quality
- ➢ Higher quality reflected with UMO feed
  - ✓ Re-refining can now produce Group II and Group III qualities



Source - KEPC

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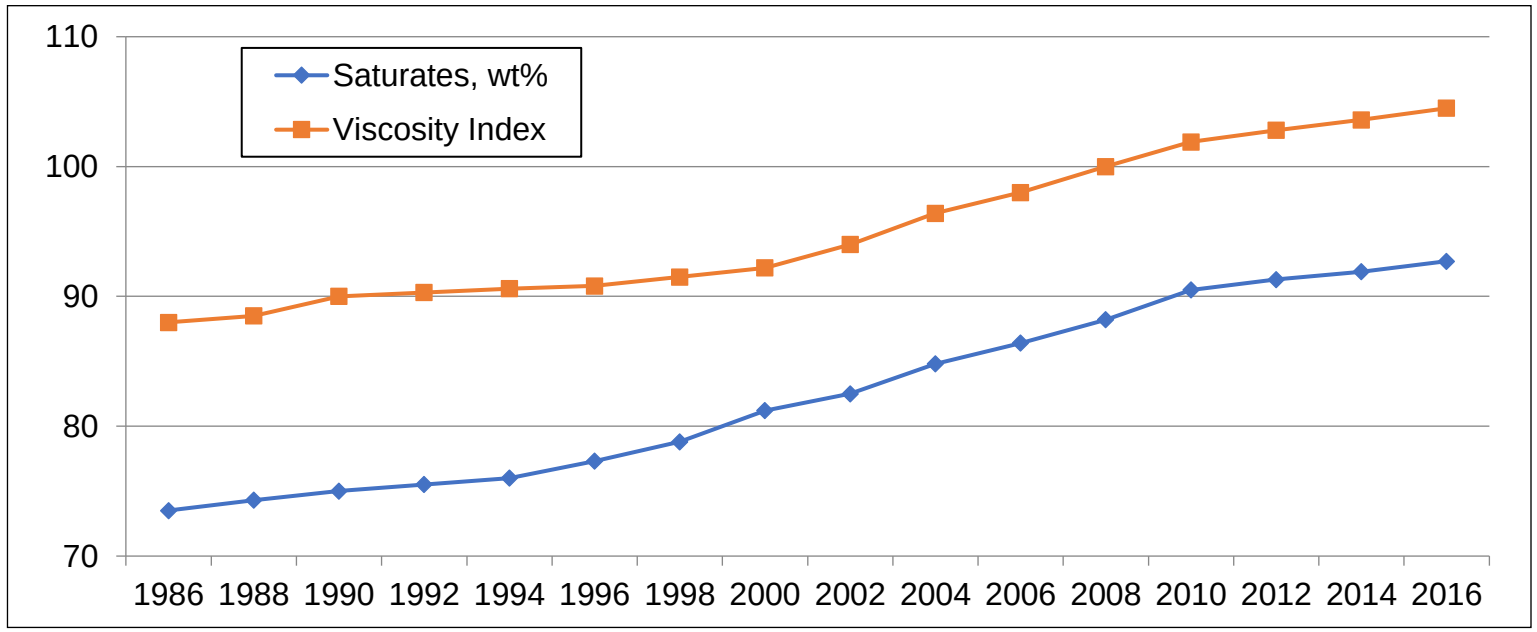
Re-Refined Base Stock Quality

- **Improved re-refined base stock quality consistent with feed quality improvements and manufacturing advancements**
  - Some companies report VI increases of 1-3 unit/year over the past decade from feed alone
  - Corresponding improvement with saturates and sulfur contents
  - Sulfur content decreased from ~1,000 ppm to <200 ppm consistent with Group II-III limits
- **Group II and Group III RRBO now a reality!**



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Opportunities with Re-Refined Base Stocks

❑Key elements of a base stock for high performance engine oils and industrial oils

- ➢ High Viscosity Index
- ➢ Good low temperature viscometrics
- ➢ Low volatility
- ➢ High saturates
- ➢ Low sulfur
  - ✓ Some Group II RRBO food grade approved
- ➢ Bright and clear
- ➢ Water and contaminant free
- ➢ Quality consistency
- ➢ Low Carbon Footprint

All of these can be achieved with a re-refined base stock

Future of Re-Refining in Europe

- **Re-refined base stock quality increasing with industry shift to higher performance and lower SAE grades**
  - Requires hydroprocessed Group II and Group III base stocks
  - Higher VI, higher saturates, lower sulfur, increased stability
- **Process technology continues to advance**
  - High pressure hydrotreating; improved catalysts
  - Solvent extraction low-cost option to hydrotreating
- **Collection is the key**
  - You make what you collect
- **Studies show re-refined base stocks are sustainable**
  - Produces up to 78% less carbon dioxide equivalent versus crude oil
  - Can contribute towards reduced greenhouse gas emissions
- **Re-refined base stocks capable of formulating mid and top tier engine oils with FE claims**
  - Conventional, semi-synthetic, synthetic

Thank you

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